Verhandlungen der k.k. Zoologische botanischen Gesellschaft in Wien. (1867, vol. ii.) This volume, like its predecessors, contains valuable additions to zoological and botanical literature. By far the most important papers contained in it are Dr. L. Koch's notes on Japanese *Arachnida* and *Myriapoda*, and Herr H. B. Möschler's remarks on the *Lepidoptera* fauna of Surinam, continued from a former volume. Of other interesting papers we note:—Lichenological excursions in the Tyrol, by F. Arnold.—On the spiders of Uruguay and other parts of America, by E. Keyserling.—Introduction to the monography of *Phanero-pterida*, by Brunner von Wattenwyl.—Hymenopterological notes, by F. F. Kohl.—On the flora of the Ionian Islands of Corfu, Cephalonia and Ithaca, by G. C. Spreitzenhofer.—On a species of *Aphis, Pemphigus Zeae Maïdis*, L. Duf, which attacks Indian corn, by Dr. Franz Löw.—Notes on the *Aeolidiadae*, by Dr. Rudolph Bergh.—On the Brazilian ants collected by Prof. Trail, by Dr. Gustav Mayr.—There are also in this volume some smaller communications from the botanical laboratory of Dr. H. W. Reichardt.

SOCIETIES AND ACADEMIES

London

Royal Society, April 11.—"On Stresses in Rarefied Gases arising from Inequalities of Temperature," by J. Clerk-Maxwell, F.R.S., Professor of Experimental Physics in the University of Cambridge.

1. In this paper I have followed the method given in my paper "On the Dynamical Theory of Gases" (*Phil. Trans.* 1867, p. 49). I have shown that when inequalities of temperature exist in a gas, the pressure at a given point is not the same in all directions, and that the difference between the maximum and the minimum pressure at a point may be of considerable magnitude when the density of the gas is small enough, and when the inequalities of temperature are produced by small solid bodies at a higher or lower temperature than the vessel containing the gas.

2. The nature of this stress may be thus defined; let the distance from the given point, measured in a given direction, be denoted by h, and the absolute temperature by θ; then the space-variation of the temperature for a point moving along this line will be denoted by $\frac{d\theta}{dh}$, and the space-variation of this quantity along the same line by $\frac{d^2\theta}{dh^2}$. There is in general a particular direction of the line h, for which $\frac{d^2\theta}{dh^2}$ is a maximum, another for which it is a minimum, and a third for which it is a maximum-minimum. These three directions are at right angles to each other, and are the axes of principal stress at the given point; and the part of the stress arising from inequalities of temperature is in each of these principal axes a pressure equal to—

$$3\frac{\mu^2}{\rho\theta}\,\frac{d^2\theta}{dh^2},$$

where μ is the coefficient of viscosity, ρ the density, and θ the absolute temperature.

3. Now, for dry air at 15° C., $\mu = 1{\cdot}9 \times 10^{-4}$ in centimetre-gramme-second measure, and $\frac{3\mu^2}{\rho\theta} = \frac{1}{p}\,0{\cdot}315$, where p is the pressure, the unit of pressure being one dyne per square centimetre, or nearly one-millionth part of an atmosphere.

If a sphere of one centimetre in diameter is T degrees centigrade hotter than the air at a distance from it, then, when the flow of heat has become steady, the temperature at a distance of r centimetres will be

$$\theta = T_0 + \frac{T}{2r}, \text{ and } \frac{d^2\theta}{dr^2} = \frac{T}{r^3}.$$

Hence, at a distance of one centimetre from the centre of the sphere, the pressure in the direction of the radius arising from inequality of temperature will be—

$$\frac{T}{p}\,0{\cdot}315 \text{ dynes per square centimetre.}$$

4. In Mr. Crookes's experiments the pressure, p, was often so small that this stress would be capable, if it existed alone, of producing rapid motion in small masses.

Indeed, if we were to consider only the normal part of the stress exerted on solid bodies immersed in the gas, most of the phenomena observed by Mr. Crookes could be readily explained.

5. Let us take the case of two small bodies symmetrical with respect to the axis joining their centres of figure. If both bodies are warmer than the air at a distance from them, then in any section perpendicular to the axis joining their centres, the point where it cuts this line will have the highest temperature, and there will be a flow of heat outwards from this axis in all directions.

Hence $\frac{d^2\theta}{dh^2}$ will be positive for the axis, and it will be a line of maximum pressure, so that the bodies will repel each other.

If both bodies are colder than the air at a distance, everything will be reversed; the axis will be a line of minimum pressure, and the bodies will attract each other.

If one body is hotter, and the other colder, than the air at a distance, the effect will be smaller; and it will depend on the relative sizes of the bodies, and on their exact temperatures, whether the action is attractive or repulsive.

6. If the bodies are two parallel discs, very near to each other, the central parts will produce very little effect, because between the discs the temperature varies uniformly and $\frac{d^2\theta}{dh^2} = 0$. Only near the edges will there be any stress arising from inequality of temperature in the gas.

7. If the bodies are encircled by a ring having its axis in the line joining the bodies, then the repulsion between the two bodies, when they are warmer than the air in general, may be converted into attraction by heating the ring, so as to produce a flow of heat inwards towards the axis.

8. If a body in the form of a cup or bowl is warmer than the air, the distribution of temperature in the surrounding gas is similar to the distribution of electric potential near a body of the same form, which has been investigated by Sir W. Thomson.[1] Near the convex surface the value of $\frac{d^2\theta}{dh^2}$ is nearly the same as if the body had been a complete sphere, namely, $2T\frac{1}{a^2}$, where T is the excess of temperature, and a is the radius of the sphere. Near the concave surface the variation of temperature is exceedingly small. Hence the normal pressure on the convex surface will be greater than on the concave surface, as Mr. Crookes has shown by the motion of his radiometers.

Since the expressions for the stress are linear as regards the temperature, everything will be reversed when the cup is colder than the surrounding air.

9. In a spherical vessel, if the two polar regions are made hotter than the equatorial zone, the pressure in the direction of the axis will be greater than that parallel to the equatorial plane, and the reverse will be the case if the polar regions are made colder than the equatorial zone.

10. All such explanations of the observed phenomena must be subjected to careful criticism. They have been obtained by considering the normal stresses alone, to the exclusion of the tangential stresses; and it is much easier to give an elementary exposition of the former than of the latter.

If, however, we go on to calculate the forces acting on any portion of the gas in virtue of the stresses on its surface, we find that when the flow of heat is steady, these forces are in equilibrium. Mr. Crookes tells us that there is no molar current, or wind, in his radiometer vessels. It may not be easy to prove this by experiment, but it is satisfactory to find that the system of stresses here described as arising from inequalities of temperature will not, when the flow of heat is steady, generate currents.

11. Consider, then, the case in which there are no currents of gas, but a steady flow of heat, the condition of which is

$$\frac{d^2\theta}{dx^2} + \frac{d^2\theta}{dy^2} + \frac{d^2\theta}{dz^2}\ (= -\Delta^2\theta) = 0.$$

(In the absence of external forces, such as gravity, and if the gas in contact with solid bodies does not slide over them, this is always a solution of the equations, and it is the only permanent solution.) In this case the equations of motion show that every particle of the gas is in equilibrium under the stresses acting on it.

Hence any finite portion of the gas is also in equilibrium; also, since the stresses are linear functions of the temperature, if we superpose one system of temperatures on another, we also superpose the corresponding systems of forces. Now the sys-

[1] Reprint of Papers on Electrostatics, p. 178.

tem of temperatures due to a solid sphere of uniform temperature, immersed in the gas, cannot of itself give rise to any force tending to move the sphere in one direction rather than in another. Let the sphere be placed within the finite portion of gas which, as we have said, is already in equilibrium. The equilibrium will not be disturbed. We may introduce any number of spheres at different temperatures into the portion of gas, and when the flow of heat has become steady, the whole system will be in equilibrium.

12. How, then, are we to account for the observed fact that forces act between solid bodies immersed in rarefied gases, and this, apparently as long as inequalities of temperature are maintained?

I think we must look for an explanation in the fact discovered in the case of liquids by Helmholtz and Piotrowski,[1] and for gases by Kundt and Warburg,[2] that the fluid in contact with the surface of a solid must slide over it with a finite velocity in order to produce a finite tangential stress.

The theoretical treatment of the boundary conditions between a gas and a solid is difficult, and it becomes more difficult if we consider that the gas close to the surface is probably in an unknown state of condensation. We shall, therefore, accept the results obtained by Kundt and Warburg on their experimental evidence.

They have found that the velocity of sliding of the gas over the surface due to a given tangential stress varies inversely as the pressure.

The coefficient of sliding for air on glass was found to be $\lambda = \frac{10}{p}$ centimetres, where p is the pressure in millionths of an atmosphere. Hence at ordinary pressures λ is insensible, but in the vessels exhausted by Mr. Crookes it may be considerable.

Hence if close to the surface of a solid there is a tangential stress, S, acting on a surface parallel to that of the body, in a direction h, parallel to that surface, there will also be a sliding of the gas in contact with the solid over its surface in the direction h, with a finite velocity $= S\frac{\lambda}{\mu}$.

13. I have not attempted to enter on the calculation of the effect of this sliding motion, but it is easy to see that if we begin with the case in which there is no sliding, the effect of permission being given to the gas to slide must be in the first place to diminish the action of all tangential stresses on the surface without affecting the normal stresses; and in the second place to set up currents sweeping over the surfaces of solid bodies, thus completely destroying the simplicity of our first solution of the problem.

14. When external forces, such as gravity, act on the gas, and when the thermal phenomena produce differences of density in different parts of the vessel, then the well-known convection currents are set up. These also interfere with the simplicity of the problem and introduce very complicated effects. All that we know is that the rarer the gas and the smaller the vessel, the less is the velocity of the convection currents; so that in Mr. Crookes's experiments they play a very small part.

Mathematical Society, April 11.—C. W. Merrifield, F.R.S., vice-president, in the chair.—Mr. Artemas Martin, Pennsylvania, was elected a Member, and Messrs. W. M. Hicks and T. R. Terry were proposed for election.—The Chairman, on the recommendation of the Council, nominated Messrs. Brioschi, Darboux, Gordan, Sophus Lie, and Mannheim for the honour of Foreign Membership.—Prof. H. J. S. Smith, F.R.S., vice-president, read two papers: second notice on the characteristics of the modular curves, and a note relating to the theory of the division of the circle.—Mr. Tucker communicated a letter from Prof. Tait, and read an abstract of a paper by Prof. Minchin on the astatic conditions of a body acted on by given forces, and a portion of a paper by Mr. C. Leudesdorf on certain extensions of Frullani's theorem.

Royal Astronomical Society, April 12.—Lord Lindsay, president, in the chair.—A paper was read by Capt. Abney, R.E., F.R.S., on photography at the least refrangible end of the solar spectrum, and some photographs of spectra of great interest were exhibited to the Fellows. Some discussion ensued, and Dr. De la Rue asked a question respecting colour photography; Capt. Abney attributed such phenomena to different degrees of oxidation of the spectrum. The President brought up Dr. Draper's discoveries, but Capt. Abney declined to speak upon that subject.—The Astronomer-Royal remarked upon the proposal to set up a statue of the late M. Leverrier, showing that the gratification and pride which the neighbours of such a great luminary would naturally take in setting up his monument ought not to be snatched from them by the intervention of strangers. It was also pointed out that the charter of the Society does not admit of any subscription in its corporate capacity.—Mr. Christie read a letter from Mr. Ellery upon Mars at opposition, 1877. It appeared that the planet was very ill-defined, and not much good could be done with it.—Mr. B. G. Jenkins read a paper on the transit of Mercury, summarising the history of such phenomena, and referring to the spot of light on the disc and the ring round the limb, and their variations corresponding with perihelion and aphelion transits. Mr. Chambers suggested that if this paper were published before next transit it would be of great value, whereas, according to the practice of the present editor of the *Notices*, that would not be done. Prof. Cayley, the editor, made the proper excuses for the lateness of the publication.—The Astronomer-Royal announced his intention to assist competent observers, who wished to observe the transit, by giving them the use of the telescopes which were employed for the transit of Venus.—Mr. Green read a letter from Prof. Schiaparelli on Mars as seen recently a long time after opposition, and showed some curious drawings.

Chemical Society, April 18.—W. Crookes, F.R.S., in the chair.—The following papers were read:—On terpin and terpinol, by Dr. Tilden. The author prepared crystallised terpin, $C_{10}H_{20}O_2 . OH_2$, by Wigger's process, and obtained the same compound from American and French terpentine, but did not procure any crystalline substance from the terpenes of the orange group. By the action of dilute hydrochloric acid on terpin, an oily body, terpinol, boiling 205°–215°, was obtained, having the formula, $C_{10}H_{18}O$. By the action of dry hydrochloric acid on terpinol, a dihydrochloride was prepared. The author believes that in the preparation of terpin by the ordinary process, terpinol is formed at a certain stage of the reaction. By acting on terpin with dilute sulphuric acid, a hydrocarbon, $C_{10}H_{16}$, boiling at 176°–178°, sp. gr. 0·8526 was obtained; it is optically inactive, and gives no crystalline deposit with hydrochloric acid, and no crystalline nitroso compound; the author proposes to call it terpinylene.—The poisonous principle of *Urechites suberecta*, by J. J. Bowrey. This plant grows wild in Jamaica; it has dark green leaves and large bright yellow flowers; it is locally called "nightshade." It is known to be very poisonous. The author has extracted from the fresh leaves of the plant, by the use of alcohol, water, and a temperature not exceeding 38° C., a white crystalline body, urechitin, $C_{28}H_{42}O_8$, to the presence of which the plant owes its poisonous properties. It is very soluble in hot alcohol, chloroform, and glacial acetic acid; almost insoluble in water and dilute spirit. It is intensely bitter, and very poisonous; it gives, with strong sulphuric acid, a characteristic colour reaction. The liquid passing from yellow through red to purple, a trace of nitric acid increases the rapidity of the colour-changes. If the leaves are dried at 100°, urechitoxin is obtained, either crystalline or amorphous. This substance resembles urechitin in its chemical and toxical properties. Both substances are glucosides.—The temperature at which some of the alkaloids, &c., sublime as determined by an improved method by A. W. Blyth. The author has determined the melting and subliming points of many active vegetable principles, and classed them as regards their behaviour to heat for practical purposes. He has also devised a new method for determining subliming points: it consists essentially in placing the substance on a thin cover glass floating on a bath of mercury, and examining a second cover glass placed over the substance, from time to time with a ¼-inch objective, the mercury being gradually heated.

Entomological Society, April 3.—H. W. Bates, F.L.S., F.Z.S., president, in the chair.—Miss E. A. Ormerod was elected a Member of the Society.—Mr. McLachlan remarked that the opinion expressed by Mr. J. P. M. Weale at the last meeting as to the functional purpose of the cephalic process in *Termes triniverius*, was corroborative of an observation already recorded in Hagen's "Monographie der Termiten."—Mr. F. Grut exhibited, on behalf of the Rev. T. A. Marshall, a collection of insects which that gentleman had made in the Windward Islands.—Mr. F. Smith exhibited a series of specimens of a species of "harvesting ant" sent to Mr. Darwin from Florida by Mrs. M. Treat. Three series showed a gradation from large soldiers and small workers, all having acutely dentate

[1] Wiener Sitzb., xl. (1860), p. 607.
[2] Pogg. Ann., clv. (1875), p. 337.

mandibles, to other ants of all sizes with mandibles having rounded teeth, and other specimens in which the teeth were obsolete. It was not, however, made clear whether intermediate forms of teeth were found in nests, or whether three distinct races existed. The species appeared to be identical with *Myrmica barbata* from Texas.—Mr. A. A. Berens exhibited two examples of *Thestor mauritanicus* taken on the Atlas Mountains. —Mr. McLachlan exhibited a coleopterous larva sent from Zanzibar by Dr. Kirk. He also exhibited a portion of the stem of a coffee-tree which had been bored into by this larva, and which was especially remarkable on account of the presence of a series of conical holes which opened a communicator between the inner gallery and the atmosphere.—Mr. W. C. Boyd exhibited and made some remarks on a specimen of *Pterophorus lætus* taken at Deal.—The Secretary read a paper communicated by the Rev. T. A. Marshall, entitled "Notes on the Entomology of the Windward Islands."—The Rev. H. S. Gorham communicated descriptions of new species of Cleridæ, with notes on the genera and corrections of synonymy.—Dr. D. Sharp communicated a paper on some Nitidulidæ from the Hawaiian Islands.—The Secretary read a paper by Mr. J. P. M. Weale, entitled "Notes on South African Insects," and exhibited drawings made by the author in illustration.—Mr. Wood Mason exhibited and made remarks on the insects referred to in the foregoing paper, and was followed by Mr. Meldola on the same subject.—The following papers were also communicated:—On display and dances by insects, by Mr. A. H. Swinton; and On the secondary sexual characters of insects, by Mr. J. W. Slater. —Part V. of the *Transactions* for 1877 was on the table.

Geological Society, March 20.—Henry Clifton Sorby, F.R.S., president, in the chair.—John William Head was elected a Fellow of the Society.—The following communications were read:—On the chronological value of the triassic strata of the south-western counties, by W. A. E. Ussher, F.G.S.—Note on an *Os articulare*, presumably that of *Iguanodon mantelli*, by J. W. Hulke, F.R.S., F.G.S.—Description of a new fish from the lower chalk of Dover, by E. Tulley Newton, F.G.S.—Further remarks on adherent carboniferous productidæ, by R. Etheridge, jun., F.G.S.—The submarine forest at the Alt Mouth, by T. Mellard Reade, F.G.S.

Institution of Civil Engineers, April 20.—Mr. Bateman, president, in the chair.—The papers read were descriptive of three bridges on the Punjab Northern State Railway, viz., "The Ravi Bridge," by Mr. R. T. Mallet, M. Inst. C.E.; "The Alexandra Bridge, over the Chenab," by Mr. H. Lambert; and "The Jhelum Bridge, by Mr. F. M. Avern, M. Inst. C.E.

Victoria (Philosophical) Institute, May 6.—A paper on the physical geography of the East, by Prof. J. L. Porter, LL.D., was read. A discussion ensued, in which many Eastern explorers and others took part.

Paris

Academy of Sciences, April 29.—M. Fizeau in the chair.—The following among other papers were read:—The theory of germs and its applications to medicine and surgery, by MM. Pasteur, Joubert, and Chamberland. It is shown to be possible to produce at will purulent affections either putrid or without any putrid element, or anthracic, or variable combinations of these kinds of disorder, according to the specific *microbes* that are caused to act on the living organism.—Experiments relating to the heat which may have been developed by mechanical actions in rocks, especially in clays; consequences for certain geological phenomena, notably for metamorphism, by M. Daubrée. He measured the rise of temperature produced in hard clay passed between rotating cylinders and between fluted cones; also the effect of pug-mills. In one case of pug-mill action for an hour the rise was more than 30°. For the same times, however, the heating effect is greater with cylindrical rollers.—Experiments with a view to determine the true origin of the chorda tympani, by M. Vulpian. These favour the conclusion that the nerve proceeds not from the facial nerve nor the intermediate nerve of Wrisberg, but from the trigeminus.—On magnetic rotation of the plane of polarisation of light under the influence of the earth, by M. Becquerel. Between a Jellet polariser and an analyser, with telescope and divided circle, is placed a tube (0·5 m. long) with parallel glass ends and containing sulphide of carbon. By means of terminal plane mirrors the luminous ray is successively reflected, the rotation being thus increased. The luminous ray comes to the eye after traversing the tube five times. Now, if the system be placed in the plane of the magnetic meridian, the plane of polarisation is not the same in looking north and in looking south; there was an angular differece of about 6′·5 between these positions. On the other hand, when the system is placed at right angles to the magnetic meridian, the same direction of the plane of polarisation is got, whether one looks east or west, and it is the bisecting position of the former two. The angular difference is considered due to the action of the earth.—Suppression of the return wire in use of the telephone, by M. Bourbouze. Connecting to earth by means of plates of gilt copper about 1 m. by 2 ctm., placed at 40 to 50 ctm. depth in garden soil, he got more distinct transmission.—On the transparency of coloured flames for their own radiations, by M. Gouy. Two layers of incandescent vapour, of the same density and temperature, but of very unequal thickness, give very different spectra. One cannot, from an examination of the lines of any spectrum, draw any conclusion as to the physical state of the vapours producing it, unless their thickness be known and taken into account.—On the solution of platinum in sulphuric acid, by M. Scheurer-Kestner. In apparatus of ordinary concentration the solution varies from 1 gramme to 8 grammes per ton of concentrated acid, according as the product obtained contains 94 or 99 per cent. of monohydrated acid; with fuming acid the quantity of metal may amount to 1,000 grammes. But by lowering of the boiling point and diminution of the platinum, as in Kesler's apparatus, the loss of metal may be greatly lessened. —On the vapour density of sulphide of ammonium, by M. Salet. He experimented by mixing at 80° known volumes of sulphuretted hydrogen and of ammonia; in no case was any contraction observed.—Experiments on the effects of lateral compression or crushing in geology, by M. Favre. In these experiments a layer of clay was made between two blocks of wood fixed on a piece of caoutchouc, which was first stretched and, after receiving the clay, was allowed to contract. Various phenomena of mountain chains were thus reproduced.—On the daily oscillation of the barometer, by M. Cousté. He considers it due to variations (1) in the quantity of atmospheric vapour of water, (2) in vertical ascending currents formed partly by the dilated air, but more by the water vapour developed by the sun in the low and middle layers, condensed anew in the upper layers.—Remarks on a letter of M. Wolf, on the period of daily variations of the inclination needle, by M. Faye. He gives a table of sun-spot minima covering 267 years, and showing 11·11 years as the period.—On the ultra-violet absorption spectra of earths of gasolinite, by M. Soret. The lines of a new base were observed.

CONTENTS

	PAGE
Physical Science for Artists. By J. Norman Lockyer, F.R.S.	29
The American Storm Warnings. By Jerome J. Collins	31
Gas as Fuel. By M. M. Pattison Muir	34
Fossil Flora of Great Britain. By Prof. W. C. Williamson, F.R.S.	35
Taxidermy	37
Our Book Shelf:—	
Burton's "Gold-Mines of Midian and the Ruined Midianite Cities. A Fortnight's Tour in North-Western Arabia"	38
Kennedy's "To the Arctic Regions and Back in Six Weeks, being a Summer Tour to Lapland and Norway, with Notes on Sport and Natural History"	38
Letters to the Editor:—	
Eastward Progress of Terrestrial Magnetism.—Prof. B. Stewart, F.R.S.	38
The Phonograph.—Alexander J. Ellis, F.R.S.; Prof. Silvanus P. Thompson	38
On the Use of the Virial in Thermodynamics.—A. S. H.	39
Time and Longitude.—Latimer Clark	40
Cumulative Temperature.—Wm. F. Stanley (*With Illustration*)	41
The Interior of the Earth. By Sir G. B. Airy, K.C.B., F.R.S., &c., Astronomer-Royal	41
A New Insulating Stand. By Prof. M. E. Mascart (*With Illustration*)	44
Rheostatic Machine. By Gaston Planté (*With Illustration*)	45
Geographical Notes	45
The Transit of Mercury	46
De Cailletet's Apparatus (*With Illustration*)	46
Notes	47
Academic Liberty in German Universities. By Prof. Helmholtz, F.R.S.	50
Stridulating Crustaceans	53
University and Educational Intelligence	53
Scientific Serials	53
Societies and Academies	54